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SC-05773-63/KH

SCIENTIFIC INTELLIGENCE REPORT

INTERFEROMETERS AT THE SARY SHAGAN MISSILE TEST CENTER

OSI-SR/SC/63-6
21 June 1963

CENTRAL INTELLIGENCE AGENCY
Office of Scientific Intelligence

Project Officer

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PREFACE

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The [redacted] Photographic Mission [redacted] revealed the existence of a large instrumentation and support complex in the vicinity of the 1,050 nautical-mile impact area of the Kapustin Yar Missile Test

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[redacted] that this area is the Soviet missile-defense research and development center. This center has been named the Sary Shagan Missile Test Center and has been the subject of continuing intensive study.

A large number of instrumentation sites associated with the Sary Shagan Missile Test Center are known to support devices closely resembling radio frequency interferometers. This paper presents an analysis of those interferometers in an attempt to identify more precisely their role in the Sary Shagan activities and in the Soviet ballistic missile program as a whole. A detailed technical discussion of radio-frequency interferometers used as tracking devices is given in the appendix.

Several similar interferometers near the Soviet ICBM impact area on the Kamchatka Peninsula, which may also be associated with the Soviet antiballistic missile program, are not covered in this report.

The cutoff date for this information is 1 July 1962.

TECHNICAL FOREWORD

A radio-frequency tracking interferometer is a device used to provide primary tracking data on both aircraft and missiles. In its simplest form, it consists of a set of antennas carefully laid out on a large antenna field. When used in conjunction with appropriate receiving equipment, this array measures the angle of arrival of a radio signal. If the signal originated from a transmitter on board the target, the angle-of-arrival measurements yield the interferometer-target line-of-sight angles directly. In principle, these measurements can be made very precise by increasing the frequency of operation and/or increasing the size of the antenna array. The range of the target can also be measured by interrogating the beacon from the interferometer or by phase locking the beacon signal to a ground-transmitted signal.

Another mode of operation involves illuminating the target with ground-based radars and receiving the reflected signal at the interferometer. The principles are the same, but the means of generating the tracking signal is different. A number of technical problems are connected with using a reflected signal, but such a scheme is feasible and does eliminate the necessity of providing a beacon transmitter. It may also be possible to extract additional information from this reflected signal. For example, methods similar to those employed in radioastronomy might yield some estimate of the size of the object being tracked.

Tracking interferometers have found their greatest application for missile-range instrumentation. They have the advantages of supplying tracking data of high accuracy on a real-time basis and at a moderate cost.

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25X1D

FIGURES (Continued)

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INTERFEROMETERS AT THE SARY SHAGAN MISSILE TEST CENTER

PROBLEM

To determine the characteristics and functions of the nine cruciform-structured interferometers at the Sary Shagan Missile Test Center, and to establish the significance of those instruments in the Soviet antiballistic missile program.

CONCLUSIONS

1. The nine cruciform-structured interferometers that are deployed around the general impact area at the Sary Shagan Missile Test Center are probably radio-frequency interferometers that are used as tracking devices. The specific characteristics of the individual interferometers cannot be determined with any degree of certainty.

2. The capability of the interferometer complex at Sary Shagan to track several high-performance targets over a large volume of space simultaneously and with considerable precision undoubtedly serves an important role in support of the Soviet antiballistic missile (ABM) research and development efforts. However, an analysis of this instrumentation yields no specific clues as to the character of the Soviet ABM program.

3. Of the possible alternatives it appears most likely that the interferometers at Sary Shagan track a target-borne, unmodulated beacon at a frequency between 60 and 600 megacycles. The overall instrument accuracy is estimated to be between 100 and 500 parts per million (ppm) in direction cosine,* although there is some chance that the accuracy is better than 100 ppm.

4. The Sary Shagan interferometers are most probably used to provide primary and very precise tracking of missiles both fired into the Sary Shagan area from launch points along the Kapustin Yar Missile Test Range and fired from the launch points within the Sary Shagan Complex. It is very unlikely that the interferometers are used to make other measurements, such as apparent re-entry vehicle size.

5. Missile-range instrumentation is probably the only use made of the Sary Shagan interferometers, and they almost certainly are not part of any operational weapons system.

*Direction cosines (of a directed line in space). The cosines (l, m, n) of the three angles between the line and the positive directions of a rectangular Cartesian coordinate system. They satisfy the relation $l^2 + m^2 + n^2 = 1$.

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6. In view of the estimated interferometer accuracies, the overall Complex might well be capable of optimum, absolute tracking accuracies of between 10 and 50 feet on any given target within the Sary Shagan area. Depending upon the power of the tracking signal, track could well be initiated at ranges in excess of 500 nautical miles. However, at long ranges the tracking accuracy is considerably degraded.

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7. Since the first photographic coverage of Sary Shagan in [redacted] new interferometers have been constructed and existing ones modified to improve their accuracy. Whether or not these modifications reflect a milestone in Sary Shagan's program cannot be determined, but the modifications support other evidence related to the continued expansion of the Sary Shagan operations.

DISCUSSION

INTRODUCTION

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Ever since Westerners first photographed it in [redacted] the Sary Shagan impact area instrumentation complex has been the subject of extensive but not always fruitful analysis. One of the major problems posed by this instrumentation complex is the presence of the crossed-baseline interferometers at nine of the ten impact-area instrumentation sites. While the presence of tracking interferometers on a missile range is not in itself surprising, the large number of interferometers at Sary Shagan and the particular configuration observed there are not easily understood in terms of usual range instrumentation practices. Apparently, the Sary Shagan interferometers reflect some special instrumentation requirements that are closely related to the antiballistic missile program being carried out there.

Physical Characteristics and Layout of the Interferometer Complex at Sary Shagan

Instrument Site 1 on the shore of Lake Balkhash and at Instrument Sites 3, 4, 5, 6, 7, 8, 9, 11, and 12 in the impact area of the Sary Shagan Missile Test Center have interferometers (see figure 1). 1/ 3/ 4/ With the exception of Sites 3 and 6 and the possible exception of Sites 1 and 8, the interferometer at each site is the primary instrument. Sites 3 and 6 are substantially larger than the others, and each contains a 110-foot dome and a smaller dome in addition to the interferometer. Site 8 is also somewhat larger and supports several radar and

[redacted]

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site has been studied for clues to the characteristics of the other interferometers, it will not be covered in detail in this report. The remaining

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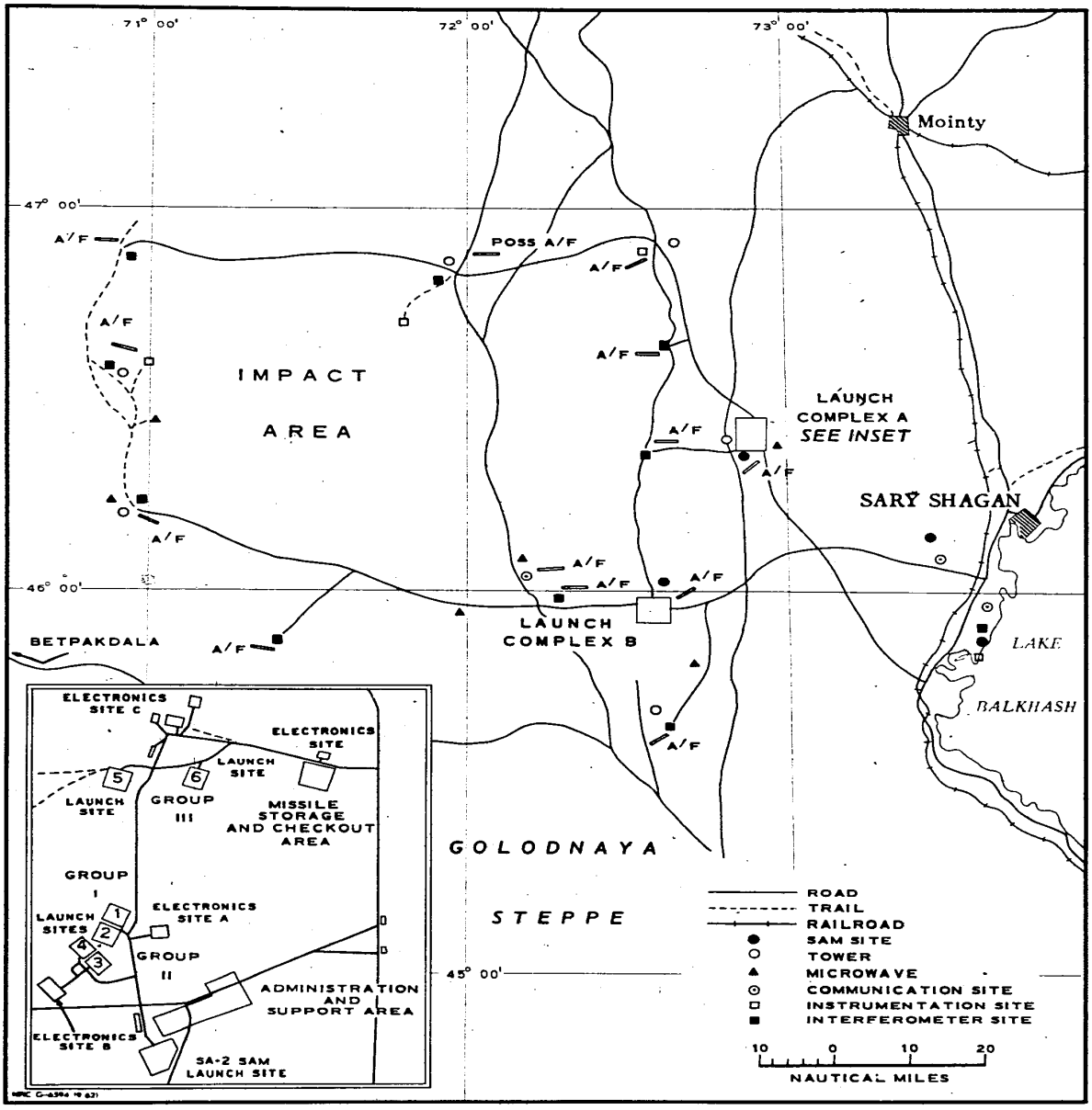

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Figure 1.
SARY SHAGAN MISSILE TEST CENTER
SHOWING THE LOCATIONS OF THE MAJOR INSTRUMENT SITES

25X1

sites, however, were apparently constructed specifically to support the interferometers at those sites and, except for several 20-foot domes at Sites 4, 7, 8, and 12, contain no other apparent installations.

25X1D Sary Shagan as of [redacted] not all of the interferometers that are now at Sary Shagan were in evidence. While Site 3 was covered by excellent quality, cloud-free photography, there was no sign of an interferometer or related construction activity. Site 6 was seen through heavy clouds; and although the interferometer was probably there, it was not detected at that time. No interferometer was seen at Site 9 either, but in this case the support area configuration clearly marked it as an interferometer support complex. 1/ Of the remaining sites, only Sites 1, 4, 7, and 8 were seen on good quality photography. Site-5 coverage was the worst of all; and beyond establishing that there was, in fact, an interferometer there, analysis yielded no detailed information on the site configuration.

In all cases where interferometers were actually seen on the [redacted] photography, they had one remarkable feature in common: the

25X1B [redacted]

The antenna fields appear as areas of smoothed earth which have been carefully leveled. The whole configuration has been constructed so that the surface of the "circular road" and the surface of the antenna field itself are coplanar. In some cases, considerable grading and earth moving was necessary to achieve this configuration. Most frequently the photography suggests that the antenna field and surface of the "road" are several feet above the level of the surrounding terrain.

Of the interferometers observed on the [redacted] photography, all but the interferometers at Sites 1 and 4 were in various stages of construction. Sites 1 and 4 were both covered with excellent quality [redacted] photography, and available evidence indicates that these instruments were operational in [redacted] Although no antennas can be seen on either antenna field, the scale of photography does not preclude their existence. The antenna fields of these two inter-

25 25X1D

[redacted]

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not near enough to completion to be classified and no details whatsoever can be read from the Site-5 coverage. 7/

All of the sites seen on the [redacted] coverage (again with the exception of Site 5) have two

25X [redacted]

ers are sunken below the surface of the antenna fields and are large enough to house the necessary interferometer electronics. The baseline length is of particular importance in that the baseline and the operating frequency are the two parameters which determine the basic precision of the instrument. The existence and size of the bunkers and the scarring on the antenna fields strongly support the contention that these devices are, in fact, interferometers.

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Changes Subsequent to [redacted] --Until [redacted] the [redacted] coverage of Sary Shagan, aside from establishing the existence of

25X1D 25X

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25X1D [redacted]

Figure 2.
SARY SHAGAN INSTRUMENT SITE

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Figure 3. SARY SHAGAN INSTRUMENT SITE

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25X1D [redacted]

Figure 4.
SARY SHAGAN INSTRUMENT SITE

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Figure 5. SARY SHAGAN INSTRUMENT SITE

25X1

25X

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25X1D [redacted]

Figure 6. SARY SHAGAN INSTRUMENT SITE

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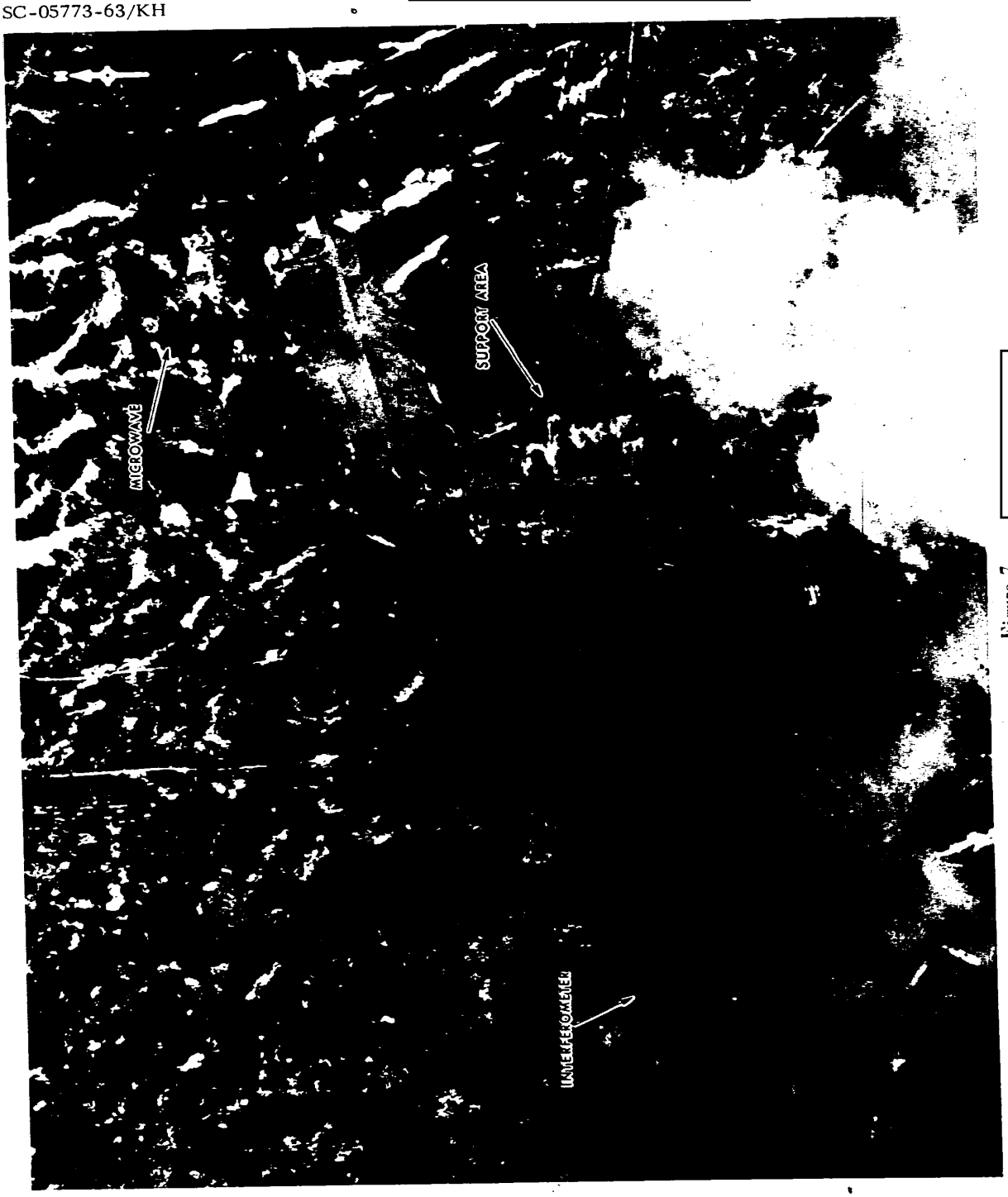

Figure 7.
SARY SHAGAN INSTRUMENT SITE

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Figure 8. SAMOS SHAGAN INSTRUMENT SITE [redacted]

interferometers at Sites 3, 6, and 9, was not of sufficient quality to yield any detailed information on the interferometers. However, photography from both [redacted] and [redacted] was of excellent quality and revealed striking changes in almost all of the interferometers. 3/ 8-14/ With the exception of the interferometers at Sites 1, 12, and possibly 6, all interferometers have been modified to the cruciform type with the crossarms extending all the way to the 1,000-foot "circular road". (See figures 9-18.) The Site-1 interferometer appears to be under construction, but there is nothing to indicate that it will ultimately resemble the other interferometers. The Site-6 interferometer was not covered on [redacted] this particular interferometer is not so clearly cruciform in shape as are the others. The Site-12 interferometer photography was of excellent quality on both [redacted] In this case, the antenna field does not extend all of the way to the "circular road," but rather is cruciform in shape with crossarms about 500 feet in length. There are no indications of any construction activity at the Site, so evidently this interferometer is still operational in its original configuration with a baseline of approximately 400 feet.

From the [redacted] coverage in [redacted], it is clear that, with the possible exceptions of the interferometers at Sites 3, 5, 6, and 9, all of the interferometers were initially intended to have a baseline of about 400 feet and an antenna field, either square or cruciform, with a characteristic dimension of about 500 feet. Again with

[redacted]

configuration, while little can be said about the Site-6 interferometer. The Site-1 interferometer is apparently undergoing alterations. A summary of the primary interferometer features as seen in [redacted] are compared in table 1.

The [redacted] photography has also yielded very precise determinations of the distances between the interferometers and their relation to the rest of the complex. As relative position is always important in any discussion of range instrumentation, these measurements are presented in table 2, along with the orientation of the crossarms in table 3. 15/ 16/

General Function and Purpose of the Interferometers

There are three possible applications of interferometers in the missile-related context in which they are seen at Sary Shagan: The ways in which they may be used are in the order of from least to most probable as follows:

1. Size measuring devices to determine the physical size of missiles fired into the impact area. In that case, the interferometer would be used somewhat like radioastronomers use interferometers to measure the angular size of radio sources of astronomical interest.
2. Angular tracking devices in an operational defense system, or
3. Tracking instrumentation to obtain tracking data in support of the Sary Shagan/Kapustin Yar activities.

Possible Use of the Interferometers as Size Measuring Devices.--It is more likely that the Sary Shagan interferometers are tracking interferometers and not size measuring instruments. Interferometers have never been used in the second sense in the U.S. re-entry measurements program, but the possibility of doing so has been considered. 17/ 18/ In this mode of operation, the targets to be examined would have to be il-

25X1D [redacted]

Figure 9. SARY SHAGAN INSTRUMENT SITE

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Figure 10. SARY SHAGAN INSTRUMENT SITE

25X1D [redacted]

GROUP 1
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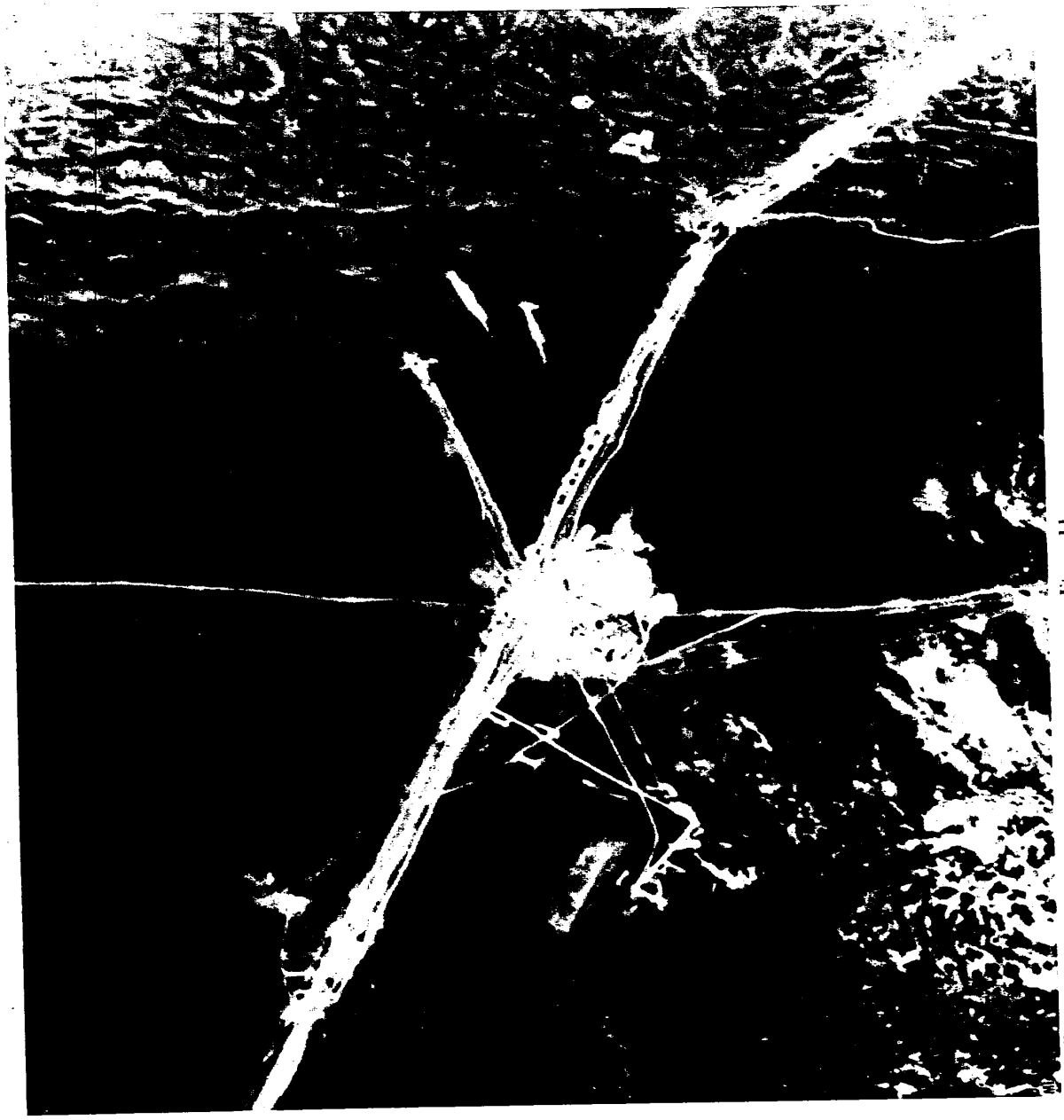

25X1D [redacted]

Figure 11. SARY SHAGAN INSTRUMENT SITE

Figure 12. SARY SHAGAN INSTRUMENT SITE

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GROUP 1
EXCLUDED FROM AUTOMATIC DOWNGRADING AND DECLASSIFICATION

25X1D [redacted]

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Figure 13. SARY SHAGAN INSTRUMENT SITE [redacted]
25X1

GROUP 1
EXCLUDED FROM AUTOMATIC DOWNGRADING AND DECLASSIFICATION

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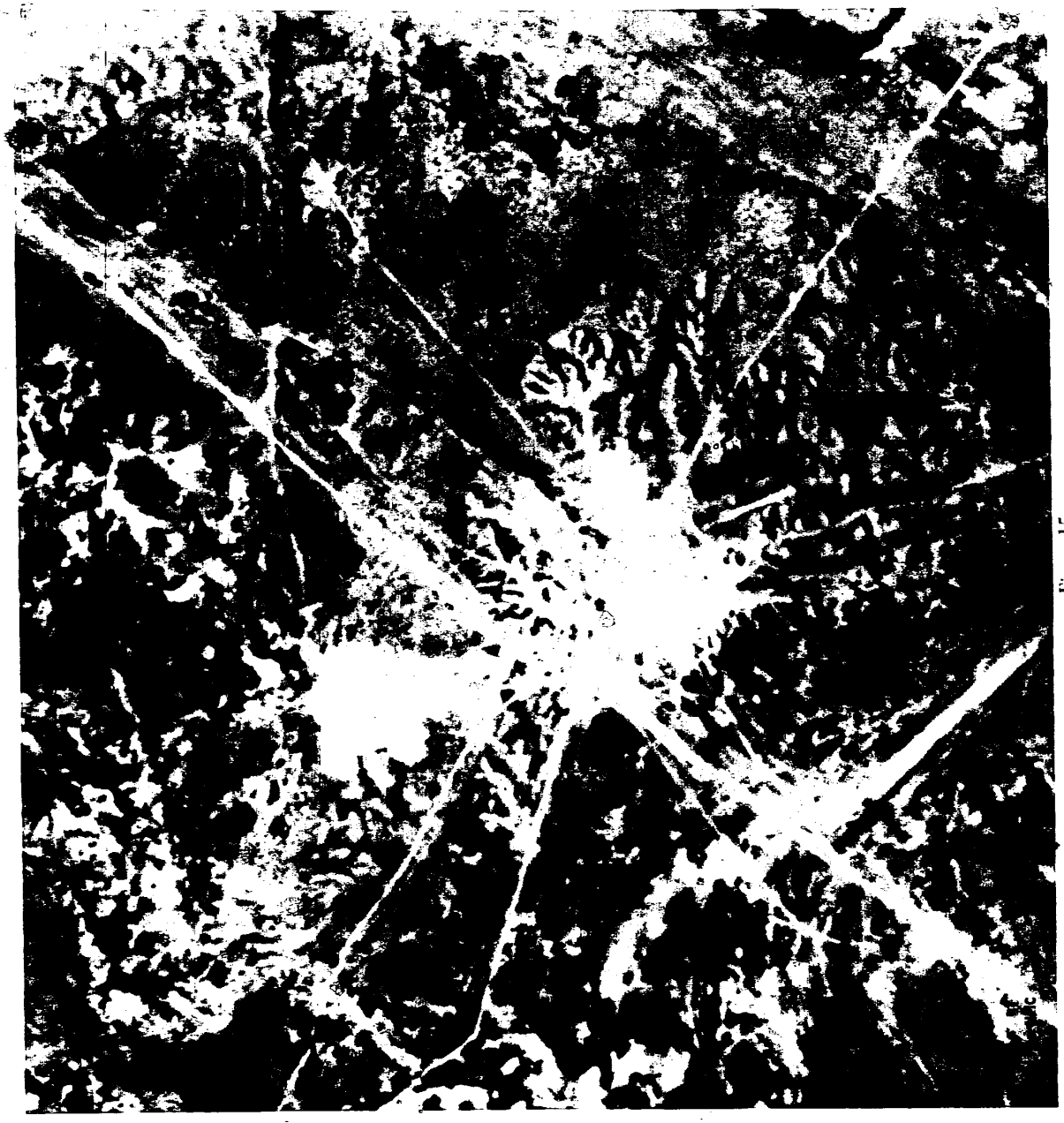
GROUP 1
EXCLUDED FROM AUTOMATIC DOWNGRADING AND DECLASSIFICATION

Figure 14. SARY SHAGAN INSTRUMENT SITE

25X1D [redacted]



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GROUP 1
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Figure 15
SARY SHAGAN INSTRUMENT SITE [redacted]

25X1D [redacted]

Figure 16. SARY SHAGAN INSTRUMENT SITE

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GROUP 1
EXCLUDED FROM AUTOMATIC DOWNGRADING AND DECLASSIFICATION

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25X1D

Figure 17.
SAMY SHAGAN INSTRUMENT SITE

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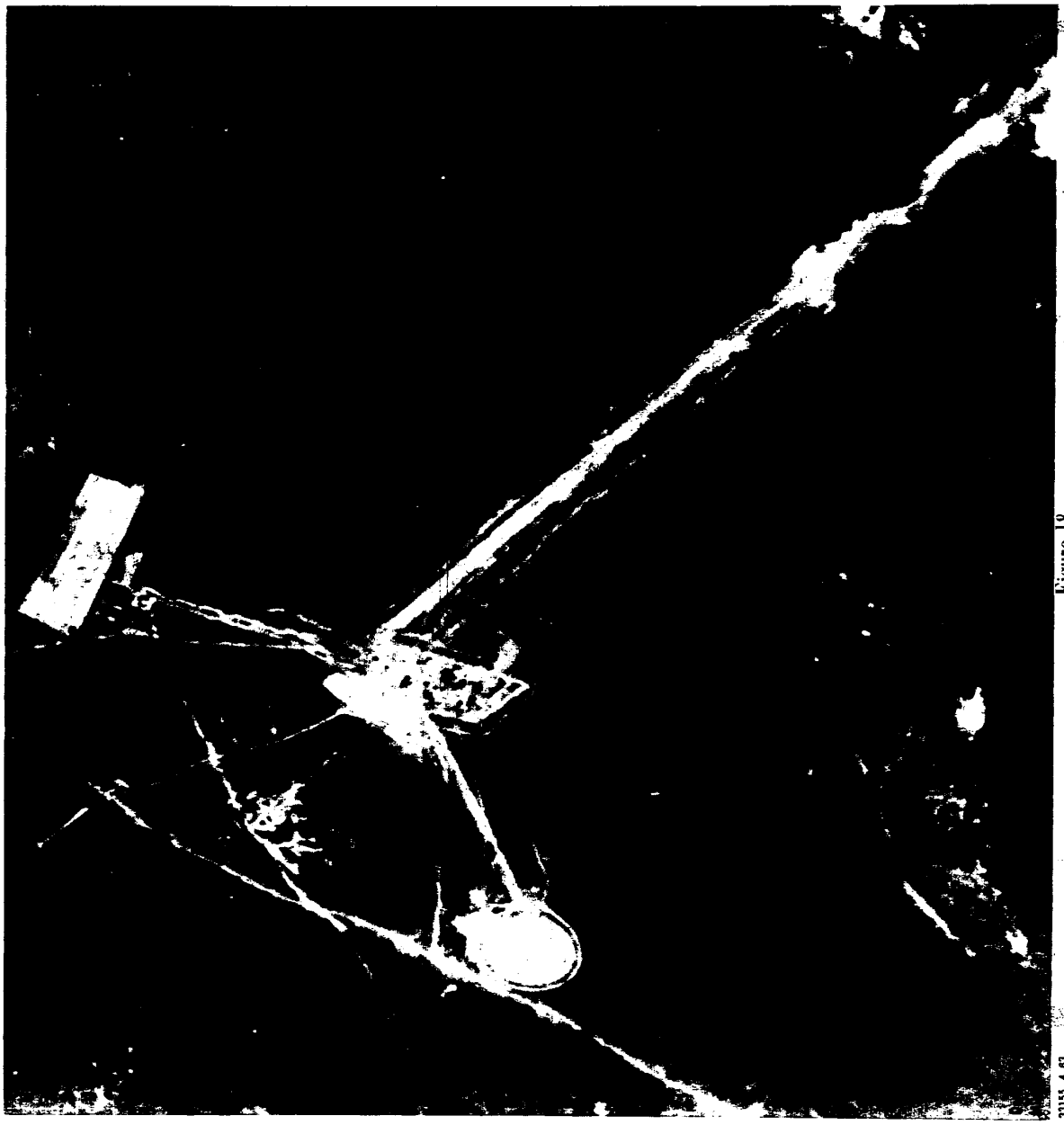

25X1D [redacted]

Figure 18. SARY SHAGAN INSTRUMENT SITE

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GROUP 1
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Table 1. [redacted]

Site	Interferometer		1000' Road		Bunker		Antenna-Field Type		Baseline Length	
	[redacted]									25X1D
1	yes	yes	yes	yes	yes	yes	500' square	500' square	400'	400'
2	no	no	---a/	---	---	---	---	---	---	---
3	no	yes	---	yes	---	yes	---	1,000' cross	---	<1,000'
4	yes	yes	yes	yes	yes	yes	500' cross	1,000' cross	~400'	<1,000'
5	yes	yes	yes	yes	?	yes	?	1,000' cross	?	<1,000'
6	?b/	yes	?	yes	?	yes	?	?	?	<1,000'
7	yes	yes	yes	yes	yes	yes	500' cross	1,000' cross	400'	<1,000'
8	yes	yes	yes	yes	yes	yes	500' square	1,000' cross	400'	<1,000'
9	probablyc/	yes	?	yes	?	yes	?	1,000' cross	?	<1,000'
10	no	no	---	---	---	---	---	---	---	---
11	yes	yes	yes	yes	yes	yes	?	1,000' cross	400'	<1,000'
12	yes	yes	yes	yes	yes	yes	cross (?)	500' cross	400'	< 500'

a. Not applicable, because there is no interferometer at the Site.
b. Cannot be determined because of the poor quality of the photography.
c. Site 9 had all of the characteristics of an interferometer support facility, but a cloud covered the suspected interferometer location.

Table 2. Distances Between the Sary Shagan Interferometer (nautical miles)

Site	1	3	4	5	6	7	8	9	11
3	45.6								
4	59.0	25.5							
5	95.0	55.0	36.3						
6	114.0	75.4	56.1	26.8					
7	125.8	96.3	71.4	48.6	23.0				
8	130.6	106.2	80.9	64.0	40.2	18.1			
9	93.3	80.5	56.5	61.4	53.9	47.6	42.4		
11	62.9	63.0	46.2	69.9	74.4	75.8	74.6	32.8	
12	54.2	46.3	29.9	58.2	67.6	74.1	76.9	39.6	16.8

Table 3. True Bearing of Interferometer Crossarms

Site	True Bearing (degrees)
1	170/350 and 80/260
3	61/241 and 151/331
4	21/201 and 111/291
5	36/216 and 126/306
6	(not discernible)
7	17/197 and 107/287
8	27/207 and 117/297
9	22/202 and 112/292
11	43/223 and 113/313
12	35/215 and 125/305

luminated by ground radars, such as the HEN EGG installations. The reflected signal would then be received at the interferometers and appropriately processed to yield an estimate of the angular size of the illuminated target. It would certainly be very desirable to measure the size of re-entering missiles, not only as an aid to discrimination in a missile defense system, but also such a measurement at various frequencies would be valuable as a part of any program attempting to gain insight into missile phenomenology, in particular for re-entry effects. The most interesting of these latter effects is the development of the ionized wake as a missile re-enters the atmosphere.

Interferometers may well be capable of measuring the size and characteristics of such wakes but at IRBM velocities the ion densities

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